

WHAT IS CLAIMED IS:

- 1 1. A method of correcting for sensor drift, in color
2 calibration for a printer; said method comprising the
3 steps of:
4 printing on a printing medium a test pattern for each
5 of at least one colorant;
6 scanning a sensor, along a scanning direction, over
7 each test pattern and at least one adjoining tonal refer-
8 ence area of the medium;
9 wherein the printing step comprises disposing each
10 said test pattern next to, along the scanning direction,
11 the at least one reference area;
12 whereby said scanning step comprises the step of ex-
13 posing the sensor to each respective reference area, along
14 the scanning direction; and
15 interpreting the sensor response to each said ref-
16 erence area, to adjust the sensor response to at least one
17 part of each test pattern.
- 1 2. The method of claim 1, wherein:
2 the printing step comprises disposing each said test
3 pattern between, along the scanning direction, at least
4 two of said reference areas.
- 1 3. The method of claim 2, wherein:
2 at least two of said reference areas are unprinted
3 areas of the medium.

1 4. The method of claim 1, wherein:
2 the at least one reference area is an unprinted area
3 of the medium.

1 5. The method of claim 4, wherein:
2 the printing step comprises printing said test pat-
3 tern for each of plural colorants.

1 6. The method of claim 3, wherein:
2 the printing step comprises printing said test pat-
3 tern for each of plural colorants.

1 7. The method of claim 2, wherein:
2 the printing step comprises printing said test pat-
3 tern for each of plural colorants.

1 8. The method of claim 1, wherein:
2 the printing step comprises printing said test pat-
3 tern for each of plural colorants.

1 9. The method of claim 1, wherein:
2 the printing step comprises printing said test pat-
3 tern for each of plural colorants in succession.

1 10. The method of claim 1, wherein:
2 the printing step comprises printing as each test
3 pattern a sequence of color patches at various tonal lev-
4 els; and
5 the interpreting step comprises applying the sensor
6 unprinted-area responses to adjust the sensor response to
7 substantially each color patch in at least one of the
8 plural test patterns.

1 11. The method of claim 10, wherein:
2 the applying step comprises applying the sensor un-
3 printed-area responses to adjust the sensor response to
4 substantially each color patch in substantially all of the
5 plural test patterns.

1 12. The method of claim 11, wherein:
2 the applying step comprises interpolation between two
3 sensor unprinted-area responses obtained at ends of each
4 sequence of patches.

1 13. The method of claim 11, wherein the interpolation is
2 based upon an interpolation model selected from the group
3 consisting of:
4 an assumed mathematical function interrelating the
5 responses at the ends of each sequence, with scan posi-
6 tions within each sequence; and
7 a succession of levels separately measured for media-
8 point responses during a preliminary precalibration scan.

1 14. The method of claim 13, wherein:
2 the preliminary precalibration scan is not made auto-
3 matically in field operations but only at the factory.

1 15. The method of claim 13, wherein:
2 the preliminary precalibration scan is made automati-
3 cally in field operations but is not applied in absolute
4 terms, and rather is used only for proportioning the in-
5 terpolation between the two responses obtained at the ends
6 of each sequence of patches.

1 16. The method of claim 11, wherein:
2 the printing step comprises automatically arranging
3 some of the patch sequences for each test pattern, selec-
4 tively either side-by-side or one above the other on such
5 printing medium so as to fit an available size of such
6 medium;
7 said disposition of each sequence between two unprin-
8 ted areas is maintained notwithstanding said automatic se-
9 lective arranging; and
10 said steps of exposing said two adjoining unprinted
11 areas, and interpreting said two sensor unprinted-adjoin-
12 ing-area responses, are maintained notwithstanding said
13 automatic selective arranging;
14 whereby the method is robust to use of different
15 printing-medium sizes.

1 17. The method of claim 16, wherein:

2 the printing step comprises printing the patches,
3 within each sequence, in alternation between two extreme
4 thitherto-unprinted tonal values of the sequence;

5 whereby for each colorant, to provide a roughly con-
6 stant printing activity during the printing step:

7
8 highest and lowest tones appear side by
9 side at one end of each sequence, and

10
11 two closest-valued middle tones appear side
12 by side at an opposite end of each
13 sequence.

1 18. The method of claim 16, wherein:

2 the printing step comprises printing the patches,
3 within each sequence, in alternation between two most-
4 nearly-central thitherto-unprinted tonal values of the
5 sequence;

6 whereby for each colorant, to provide a roughly con-
7 stant printing activity during the printing step:

8
9 two closest-valued middle tones appear side
10 by side at an one end of each
11 sequence, and

12
13 highest and lowest tones appear side by
14 side at an opposite end of each
15 sequence.

1 19. The method of claim 1, wherein:
2 the printing step comprises scanning at least one
3 marking printhead along the scanning direction to form the
4 test pattern.

1 20. An apparatus for printing an image hardcopy on a
2 printing medium; said apparatus comprising:
3 at least one printhead for marking on such medium;
4 a processor for controlling the at least one print-
5 head to discharge inkdrops in a pattern to form such
6 image; and
7 means for color-calibrating the at least one print-
8 head; said means comprising:

9
10 portions of the processor for operating the
11 at least one printhead and the car-
12 riage to form a color-calibration test
13 pattern, said test pattern being
14 formed on such medium adjacent to at
15 least one reference area,

16
17 at least one light source for scanning
18 across the test pattern and the at
19 least one area to illuminate the pat-
20 tern and the at least one area,

21
22 a sensor for scanning across the pattern
23 and at least one area, with the at
24 least one source, to measure illumina-
25 ted colors in the test pattern and the
26 at least one area,

27

28 means for interpreting measurement signals
29 from the sensor, to correct the sensor
30 output signals for drift due to incom-
31 plete warmup;
32
33 said interpreting means comprising processor portions
34 for:
35
36 isolating measurement-signal segments rep-
37 resenting the at least one area to es-
38 tablish a tonal-reference calibration
39 level, and
40
41 applying the calibration level to correct
42 the measurement signals due to the
43 measured illuminated colors.

1 21. The apparatus of claim 20, further comprising:
2 a scanning carriage for carrying the at least one
3 printhead across such medium to form such image; and
4 wherein the processor comprises components for coor-
5 dinating the carriage and the at least one printhead to
6 form such image.

1 22. The apparatus of claim 20, wherein:
2 the light source comprises a light-emitting diode.

1 23. The apparatus of claim 20, wherein the interpreting
2 means comprise:

3 an analog-to-digital converter for receiving the
4 measurement signals and deriving therefrom converter out-
5 put signals representing the measurement signals; and

6 portions of the processor for interpreting the con-
7 verter output signals, to correct the converter output
8 signals for drift due to incomplete warmup.

1 24. The apparatus of claim 20, wherein:

2 each reference area is an unprinted area of such
3 printing medium;

4 whereby the tonal-reference calibration level is a
5 medium-point calibration level.

1 25. The apparatus of claim 24, wherein:

2 said at least one reference area comprises plural un-
3 printed areas of such printing medium; and

4 said test pattern is formed on such medium between at
5 least two of said plural unprinted areas.

1 26. The apparatus of claim 25, wherein:

2 the at least one printhead comprises plural print-
3 heads.

1 27. The apparatus of claim 24, wherein:

2 the at least one printhead comprises plural print-
3 heads.

1 28. The apparatus of claim 23, wherein:
2 the at least one printhead comprises plural print-
3 heads.

1 29. The apparatus of claim 23, wherein:
2 said at least one reference area comprises plural
3 reference areas; and
4 said test pattern is formed on such medium between at
5 least two reference areas.

1 30. An economical apparatus for printing an image hard-
2 copy on a printing medium, and for obtaining near-colori-
3 metric quality although said apparatus has inexpensive
4 components; said apparatus comprising:

5 at least one printhead for marking on such medium,
6 said at least one printhead being subject to marking tol-
7 erances that require color calibration;

8 at least one processor having portions for control-
9 ling the at least one printhead to discharge inkdrops in a
10 pattern to form such image; and

11 means for color-calibrating the at least one print-
12 head; said means comprising:

13
14 portions of the processor for operating the
15 at least one printhead to form a
16 color-calibration test pattern, said
17 test pattern being formed on such
18 printing medium adjacent to at least
19 one reference area, of such printing
20 medium, that provides a tonal-ref-
21 erence calibration level,

22
23 plural light-emitting diodes for scanning
24 across the test pattern and the at
25 least one reference area to illuminate
26 the pattern and the at least one area,
27 temperature dependence in the diodes
28 leading to drift of illumination level
29 during warmup,

30
31 a sensor for scanning across the pattern
32 and at least one area, with the di-
33 odes, to measure illuminated colors in
34 the test pattern and to measure the at

35 least one reference area, whereby the
36 illumination drift leads to drift of
37 measurement signals from the sensor,
38

39 an analog-to-digital converter for receiv-
40 ing the measurement signals, nonline-
41 arities in the converter making mea-
42 surements of small signal differences
43 on a large signal pedestal undesir-
44 able, wherefore the diodes are used in
45 alternation rather than continuously,
46 and therefore never fully complete
47 warmup, and
48

49 means for compensating for incomplete diode
50 warmup;
51

52 said compensating means comprising portions of the
53 processor for interpreting output signals from the conver-
54 ter, to correct the converter output signals for drift due
55 to said incomplete warmup;

56 said interpreting portions comprising processor por-
57 tions for:
58

59 isolating converter-signal segments representing
60 tonal-reference calibration level, and
61

62 applying the tonal-reference calibration-level
63 segments to correct the measurement signals
64 due to the measured illuminated colors;
65

66 whereby the apparatus accommodates the printhead tol-
67 erances and diode temperature dependence, and avoids the
68 converter nonlinearities.

1 31. The apparatus of claim 30, for use in image printing
2 based upon image data received or generated by the ap-
3 paratus; and further comprising:
4 a scanning carriage for carrying the at least one
5 printhead across such medium to form such image;
6 wherein the at least one processor also has portions
7 for coordinating the carriage and the at least one print-
8 head to form such image; and
9 wherein the processor controlling portions comprise
10 portions for performing calculations used respectively in:
11
12 color corrections to such image data if
13 desired,
14
15 rendition to exchange resolution for color
16 depth,
17
18 ink depletion to avoid placement of exces-
19 sive colorant on the printing medium,
20 and
21
22 printmasking to allocate inkdrop discharge
23 as between successive scans of the
24 scanning carriage.

1 32. The apparatus of claim 30, wherein:
2 the processor operating portions comprise means for
3 printing said test pattern in each of plural colors re-
4 spectively, and for each color as a sequence of color pat-
5 ches at various tonal levels; and
6 the processor interpreting portions comprise means
7 for applying the sensor reference-area measurements to
8 adjust the sensor measurement for substantially each color
9 patch in at least one of the plural test patterns.

1 33. The apparatus of claim 32, wherein:
2 the applying means comprise means for applying the
3 sensor reference-area measurements to adjust the sensor
4 measurement for substantially each color patch in substan-
5 tially all of the plural test patterns.

1 34. The apparatus of claim 33, wherein:
2 the applying means comprise means for interpolation
3 between two sensor reference-area responses obtained at
4 ends of each sequence of patches.

1 35. The apparatus of claim 34, wherein the interpolation
2 is based upon an interpolation model selected from the
3 group consisting of:
4 an assumed mathematical function interrelating re-
5 sponses at ends of each sequence with scan positions with-
6 in each sequence; and
7 a succession of levels separately measured for media-
8 point responses during a preliminary precalibration scan.

1 36. The apparatus of claim 35, wherein:
2 the preliminary precalibration scan is not made auto-
3 matically in field operations but only at the factory.

1 37. The apparatus of claim 35, wherein:
2 the preliminary precalibration scan is made automati-
3 cally in field operations but is not applied in absolute
4 terms, and rather is used only for proportioning interpo-
5 lation between two responses obtained at ends of each se-
6 quence of patches.

1 38. The apparatus of claim 35, wherein:
2 the processor operating portions include means for
3 printing the patches, within each sequence, in alternation
4 between two extreme thitherto-unprinted tonal values of
5 the sequence;
6 whereby for each color, to roughly stabilize the tem-
7 perature of an associated printhead:

8
9 highest and lowest tones appear side by
10 side at one end of each sequence, and
11
12 two closest-valued middle tones appear side
13 by side at an opposite end of each
14 sequence.

1 39. The apparatus of claim 35, wherein:
2 the processor operating portions include means for
3 printing the patches, within each sequence, in alternation
4 between two most-nearly-central thitherto-unprinted tonal
5 values of the sequence;
6 whereby for each color, to roughly stabilize the tem-
7 perature of an associated printhead:
8
9 two closest-valued middle tones appear side
10 by side at an one end of each
11 sequence, and
12
13 highest and lowest tones appear side by
14 side at an opposite end of each
15 sequence.

1 40. An apparatus for printing an image hardcopy on a
2 printing medium; said apparatus comprising:
3 at least one printhead for marking on such medium;
4 a processor for controlling the at least one print-
5 head to discharge inkdrops in a pattern to form such
6 image; and
7 means for color-calibrating the at least one print-
8 head; said means comprising:
9
10 portions of the processor for operating the
11 at least one printhead to form a
12 color-calibration test pattern on such
13 medium,
14
15 at least one light source for scanning
16 across the test pattern to illuminate
17 the pattern at plural scan positions,
18
19 a sensor for scanning across the pattern,
20 with the at least one source, to mea-
21 sure illuminated colors at the scan
22 positions,
23
24 guide means establishing a spacing between
25 such printing medium and at least a
26 portion of the sensor; said guide
27 means being subject to tolerances that
28 lead to nonuniformity of the spacing,
29 at the scan positions,
30
31 means for interpreting measurement signals
32 from the sensor, to correct the sensor
33 output signals for variation due to
34 said nonuniformity of the spacing;

35 said interpreting means comprising processor portions
36 for:
37 also scanning the sensor across an unprin-
38 ted region of the medium to obtain re-
39 spective unprinted-medium tonal-refer-
40 ence calibration levels for the scan
41 positions,
42
43 isolating measurement-signal segments rep-
44 resenting the tonal-reference calibra-
45 tion levels for the scan positions,
46 and
47
48 applying the isolated signal segments to
49 correct the measurement signals due to
50 the measured illuminated colors.